



AgSTAR Digest



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AgSTAR Digesters Continue Accelerating in the U.S. Livestock Market

Farm demand and use of anaerobic digesters for livestock manure stabilization and energy production have shown continued acceleration since the last edition of the Digest. Over the past two years, the number of digesters has more than doubled due to a diverse array of national, state, and local activities to market, cost share, and reliably develop operational systems. (See Figure 1.)

Digester Technology Profiles Grow

The success rate of installed systems has been extremely high and is

currently led by a growing number of engineering and equipment supply companies. European-style systems are also emerging in the U.S. market. The majority of commercially operating systems are conventional plug flow, vertically mixed plug flow, and complete mix reactors (including covered lagoons) operating at mesophilic temperatures, and covered lagoons operating at ambient temperature. (See Figure 2.) Although the majority of systems are still farm owned and operated using only livestock manure, innovative approaches are also emerging. These include commingling of high strength

organic wastes to increase gas production per unit volume of reactor, third party owned/operated centralized or regional plants, and direct gas sales to utilities that then produce power for their service territory. The majority of these systems are found in the dairy industry in the Midwest, West, and Northeast. Pig industry digester clusters are found in Texas and Utah. These systems are estimated to produce 248 million kilowatt-hours annually. (See Figure 3.)

Figure 1. Trends in methane reduction and equivalent kilowatt-hours attributed per year to anaerobic digesters – 2000 through 2006.

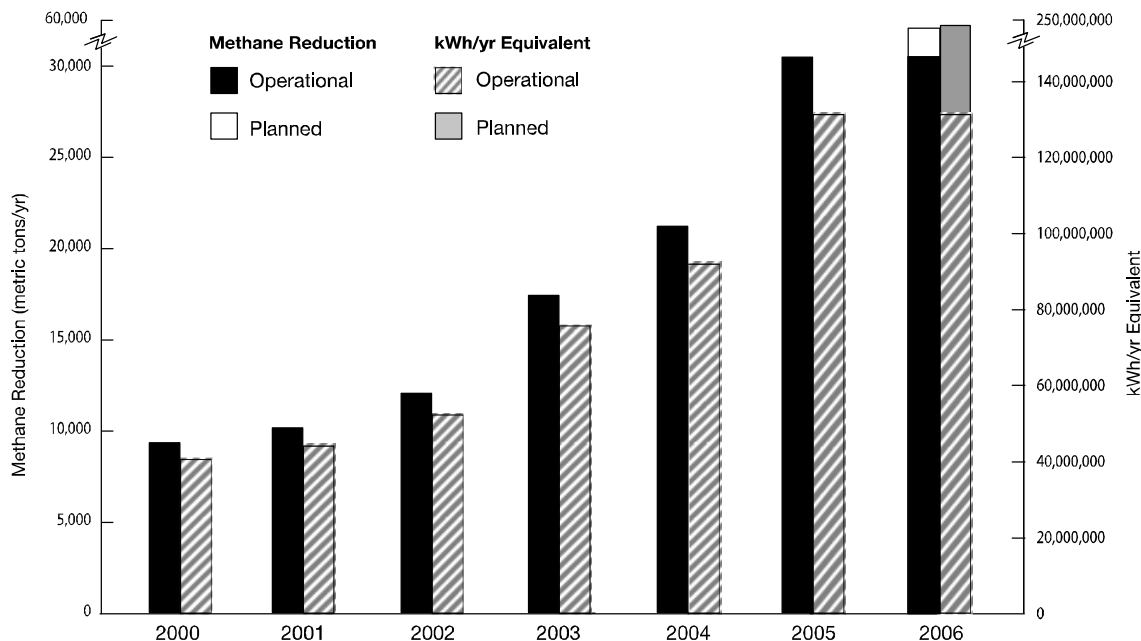
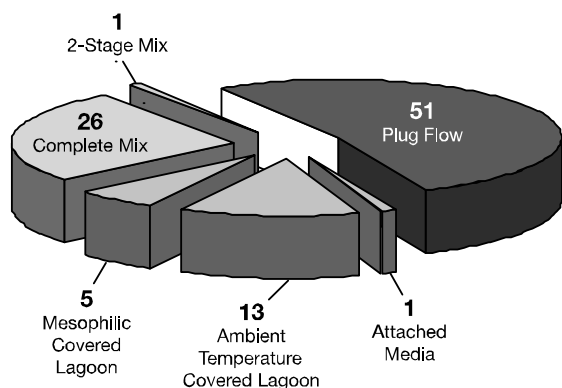


Figure 2. Operating anaerobic digesters by technology*.

*Includes digesters in start-up and construction stage.

Incentives for Growth Emerge

A number of elements have emerged to increase the deployment rate of these digester systems. For example, grants awarded under Section 9006, Renewable Energy and Energy Efficiency, of the 2002 Farm Bill have been the primary method for farms to partially fund installation of commercially proven livestock waste digestion technologies. Since 2003, a total of about \$25 million has been awarded for anaerobic digestion of livestock manures. Annual funding levels for anaerobic digesters are shown in Figure 4. State programs have also provided funding opportunities such as the California Energy Commission (see page 14 for a project success story at Hilarides Dairy), the Pennsylvania Harvest

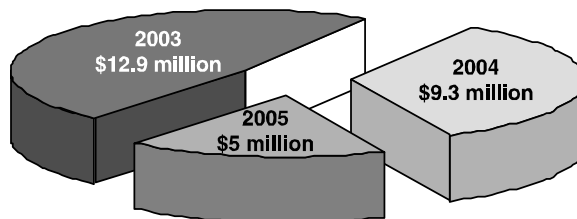
Program, the Wisconsin Focus on Renewable Energy Program, and the New York State Energy Research and Development Authority. Some of these programs are still active and some have now shifted to evaluating energy, economic, and environmental performance of operational systems. The AgSTAR program has coordinated with these agencies in a number of areas in developing these programs and providing technical assistance.

Standardized Protocol

Additionally, the AgSTAR program and the Association of State Energy

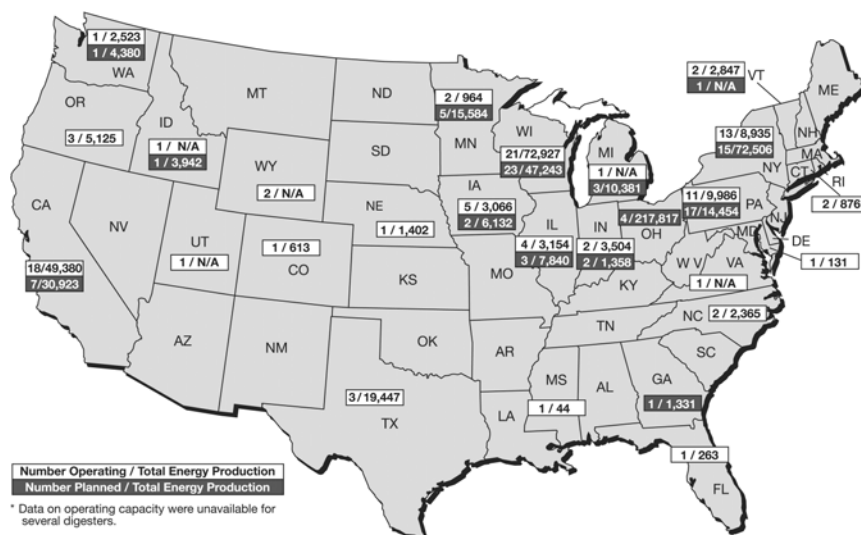
About the AgSTAR Program

The AgSTAR Program is a voluntary effort jointly sponsored by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture, and the U.S. Department of Energy. The program encourages the use of methane recovery (biogas) technologies at confined animal feeding operations (CAFOs) that manage manure as liquids or slurries. These technologies reduce greenhouse gas (methane) concentrations while achieving other environmental benefits. For additional information about the AgSTAR program, please visit our Web site at www.epa.gov/agstar.

**Figure 4.** Annual funding for anaerobic digesters.

Research and Technology Transfer Institutions are jointly developing a protocol to provide a standardized method for conducting digester performance assessments. The U.S. Department of Agriculture, U.S. Environmental Protection Agency, a number of university biological engineering departments, and digester system designers are involved in the development of this protocol. The protocol will be released at the National AgSTAR Conference April 25–26, 2006, in Madison, Wisconsin, and posted on the AgSTAR Web site. This protocol has been used to evaluate a number of digesters and other waste management processes. Reports can be found at the AgSTAR Web site.

State energy legislation has played a significant role in restructuring the methods by which farms are paid for the renewable energy they produce from digester systems. This legislation has focused on net metering as a way of providing a fair market for biogas-generated electricity. Net metering has reduced a key market barrier imposed by conventional utility rate



Number Operating / Total Energy Production
Number Planned / Total Energy Production
* Data on operating capacity were unavailable for several digesters.

Figure 3. National distribution of anaerobic digester energy production – operating and planned digesters * (Energy production in 1,000 kWh/yr).

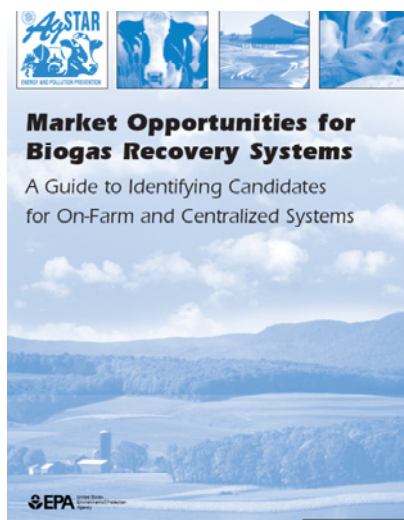
structures on grid-interconnected, independent power producers that has impeded the financial performance of distributed generation from digester technology. This has resulted in the lack of private financing for these systems. Currently, net metering legislation has been enacted in New York and Pennsylvania and is under development in California and Maryland. Various electric utilities have also created green power programs that are favorable for renewable base load generation technologies such as anaerobic digesters. For example, We Energies, Wisconsin's largest utility, received authorization from the Public Service Commission of Wisconsin (PSCW) to significantly expand its renewable energy programs. Among these programs, the PSCW approved a new "Biogas Buy-Back Rate," which pays 8.0¢/kWh for "on-peak" energy and 4.9¢/kWh for "off-peak" energy to customers who generate electricity from anaerobic digester technology using waste from animal feeding



operations, industrial food processing, or municipal wastewater treatment facilities. Central Vermont Public Service also offers the CVPS Cow Power™ program for customers who want to support renewable energy and Vermont dairy farms. By enrolling in the program customers will help support Vermont dairy farms that develop anaerobic digesters by paying a small premium on their electric service for renewable energy. In turn for every kilowatt-hour requested by customers and provided by a Vermont farm, CVPS will pay the farm-based generator the market price for energy plus the CVPS Cow Power™ charge of 4 cents for the of the energy. Carbon credits have also emerged, and the first U.S. dairy greenhouse gas reduction contract has been signed where the dairy is paid about \$2/ton CO₂ reduced annually. (See page 13.)

Market Opportunities Evaluated

Indeed, these are exciting times for anaerobic digesters and farm-based power production, as well as for other renewable energy resources. Rising energy costs, reliance on imported fossil fuels, and energy security suggest that expanded efforts are needed to realize the full potential of domestic renewable energy resources. A recently completed AgSTAR analysis and upcoming report—Market Opportunities for Biogas Recovery Systems at Animal Feeding



Operations — evaluates the anaerobic digestion market, its energy production potential, greenhouse gas reduction opportunities, and other environmental benefits that are available from domestic livestock manure resources. As shown in Table 1 (based on farm scale, waste handling method, and installed digester cost) about 7,000 farms could use anaerobic digestion cost-effectively and provide about 700 megawatts (MW) of distributed energy to rural areas while reducing greenhouse gas by about 1.3 million metric tons (MMT) of methane (CH₄), the equivalent of 30 MMT of carbon dioxide (CO₂). This would be equivalent to removing 4.7 million cars from our highways.

Table 1. Market Opportunities for Biogas Recovery Systems at Animal Feeding Operations (February 3, 2006)

Animal Sector	Candidate Farms	MW	MWh/year	CH ₄ Emission Reductions (tons/year)
Pigs	4,300	363	3,184,000	771,000
Dairy	2,600	359	3,148,000	572,000
Total	6,900	722	6,332,000	1,343,000

Digester Costs

The cost of anaerobic digestion for biogas production and utilization will vary with system type and size, type of livestock operation, and site-specific conditions. To provide some preliminary guidance with respect to expected cost, the AgSTAR program

has performed a series of analyses to determine the relationships between capital cost and size for different types of operating digesters for dairy and swine manures with internal combustion engine-generator sets. Results of these analyses in combination with other information

were used to develop the cost algorithms used in FarmWare, Version 3.0. The graphics below provide a snap shot of these relationships. (See Figures 5, 6, and 7.)

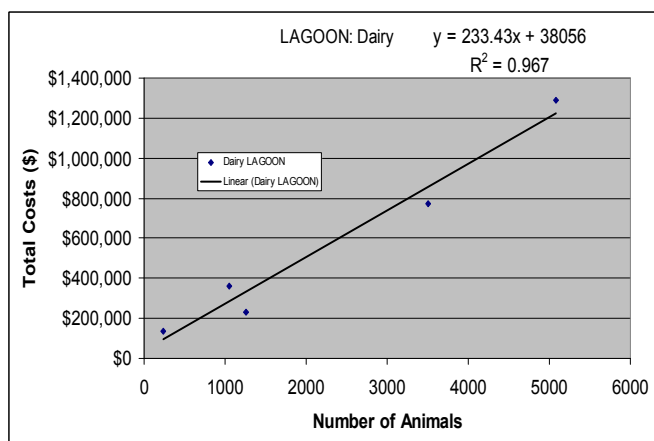


Figure 5. Covered lagoon digester cost – relationship to dairy herd size.

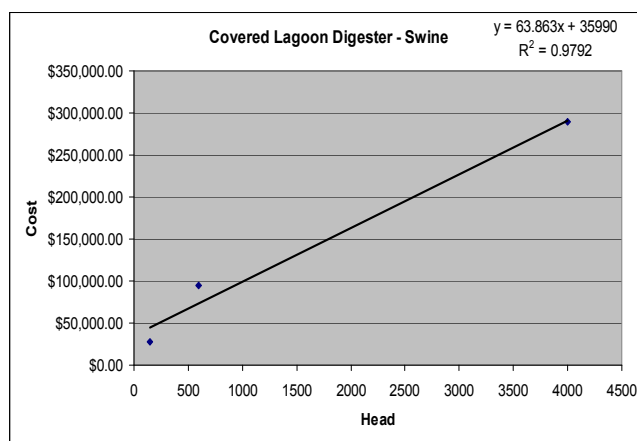


Figure 6. Analysis of covered lagoon digester system costs (swine).

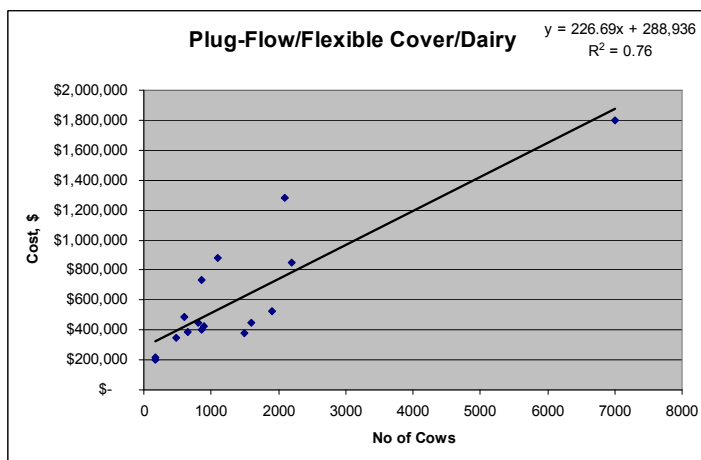


Figure 7. Plug flow/flexible cover digester system cost relationship to dairy herd size.

Digester Systems Operating

Tables 2 and 3 contain a listing of livestock-based anaerobic digestion system operating or in startup or construction mode in the United States. In addition, there are approximately 80 systems in the planning stages in the United States.

These systems represent an additional 200,000 dairy and swine plus 1.5 million layers. The electrical output of these proposed generators is estimated to be more than 400 million kWh/yr. These operations are estimated to reduce methane emissions more than 26,000 metric tons per year, which represents an

annual reduction in equivalent greenhouse gas emissions of more than 546,000 metric tons, expressed as carbon dioxide. The predominant digestion technology proposed is plug flow, followed by complete mix and heated and ambient temperature covered lagoons. Because the number of planned and operational systems

are growing rapidly, there may be additions, changes, and deletions as of this posting, and this listing does not contain the recently awarded 2005 Section 9006 anaerobic digester grants. To the extent possible, this listing provides the best quality data available in the respective fields reported. However, there may be some inaccuracies. Maintaining data

quality is a key concern and becomes more difficult to verify as systems go on- or off-line, or initial plans change. In this capacity, the AgSTAR program will be launching a database, similar to the one shown in Tables 2 and 3, on the AgSTAR Web site. Digester owner/operators, developers, extension personnel, and others will be able to add, make changes, and

correct any data that may be incorrectly reported or outdated. This updating capability will be Web-based, so that anyone wishing to update or add information can do so by e-mailing the database manager, who will then verify the data submission with the farm owner or other appropriate party.

Table 2. Operating U.S. Digesters

Location	Digester Type	Year Operational	Animal Type/Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
CA	Mesophilic, vertically mixed, plug flow, hard top, concrete tank	2004	Dairy; 3,510	Electricity	144	Lagoon	984	20,664
CA	Ambient temperature covered lagoon	2005	Dairy; 237	Electricity	900	Liquid/Slurry Storage	31	651
CA	Ambient temperature covered lagoon	2005	Dairy; 175	Electricity	27	Liquid/Slurry Storage	23	483
CA	Ambient temperature covered lagoon	2005	Dairy; 5081	Electricity	270	Liquid/Slurry Storage	665	13,965
CA	Ambient temperature covered lagoon	N/A	Dairy; 5,081	Electricity	270	Liquid/Slurry Storage	665	13,965
CA	Ambient temperature covered lagoon	2005	Dairy; 1050	Electricity	108	Liquid/Slurry Storage	137	2,877
CA	Ambient temperature covered lagoon	2005	Dairy; 6000	Electricity	225	Liquid/Slurry Storage	785	16,485
CA	Plug Flow	2005	Dairy; 4700	Electricity	506	Liquid/Slurry Storage	615	12,915
CA	Plug Flow	2005	Dairy; N/A	Electricity	1350	Liquid/Slurry Storage	N/A	N/A
CA	Mesophilic, flexible top, plug flow, concrete tank	2003	Dairy; 1,500	Electricity	234	Liquid/Slurry Storage	196	4,116
CA	Mesophilic, flexible top, plug flow, concrete tank	1982	Dairy; 400	Electricity; hot water	36	Liquid/Slurry Storage	52	1,092
CA	Ambient temperature covered lagoon	2005	Dairy; 1258	Electricity	135	Liquid/Slurry Storage	165	3,465

¹ Equivalent greenhouse gas emission reduction potential expressed as carbon dioxide. This value assumes methane has approximately 21 times the heat trapping capacity of carbon dioxide.

Location	Digester Type	Year Operational	Animal Type/ Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
CA	Mesophilic, flexible top, plug flow, concrete tank	2003	Dairy; 1,900	Electricity	144	Liquid/Slurry Storage	249	5,229
CA	Mesophilic, flexible top, complete mix, concrete tank	2001	Dairy; 5,000	Electricity; hot water	270	Liquid/Slurry Storage	654	13,734
CA	Mesophilic, hard top, plug flow, concrete tank	2002	Dairy; 7,000	Electricity	270	Liquid/Slurry Storage	916	19,236
CA	Ambient temperature covered lagoon	1982	Swine; 1,650	Electricity; hot air	45	Lagoon	58	1,218
CA	Ambient temperature covered lagoon	2000	Dairy; 200	N/A	22	Liquid/Slurry Storage	26	546
CA	Plug Flow	2005	Dairy; 600	Electricity	117	Liquid/Slurry Storage	78	1,638
CO	Mesophilic, flexible top, complete mix, concrete tank	1999	Swine; 5,000	Electricity	63	Lagoon	157	3,297
CT	Mesophilic, hard top, complete mix, above-ground metal tank	1997	Dairy; 600	Electricity	72	Liquid/Slurry Storage	53	1,113
CT	Mesophilic, flexible top, plug flow, concrete tank	1997	Dairy; 200	Hot water; flare	18	Liquid/Slurry Storage	18	378
FL	Attached media, hard top, aboveground	1999	Dairy; 250	Hot water; flare	27	Liquid/Slurry Storage	46	966
ID	N/A	N/A	Dairy; 3,000	Electricity	N/A	Lagoon	287	6,027
IA	Ambient temperature covered lagoon	1998	Swine; 3,000	Flare	0	Lagoon	76	1,596
IA	Mesophilic, hard top, plug flow, concrete tank	2002	Dairy; 380	Electricity; heat	45	Liquid/Slurry Storage	34	714
IA	Mesophilic, hard top, plug flow, concrete tank	2004	Dairy; 1,000	Electricity; hot water	90	Liquid/Slurry Storage	88	1,848
IA	Mesophilic, flexible top, complete mix, concrete tank	1998	Swine; 5,000	Electricity	54	Lagoon	166	3,486
IA	Mesophilic, hard top, plug flow, combined phase, concrete tank	N/A	Dairy; 700	Electricity	126	Liquid/Slurry Storage	62	1,302

Location	Digester Type	Year Operational	Animal Type/ Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
IL	Mesophilic, heated lagoon, combined phase	1998	Swine; 8,300	Hot water; flare	36	Lagoon	285	5,985
IL	Plug flow	2005	Dairy; 1,100	Electricity	126	Liquid/Slurry Storage	111	2,331
IL	Mesophilic, flexible top, plug flow, combined phase, concrete tank	2002	Dairy; 1,400	Electricity	162	Liquid/Slurry Storage	141	2,961
IN	Mesophilic, hard top, plug flow, concrete tank	2002	Dairy; 3,500	Electricity	360	Liquid/Slurry Storage	343	7,203
MD	Mesophilic, hard top, complete mix, vertical pour, concrete tank	1994	Dairy; 120	Flare	14	Liquid/Slurry Storage	12	252
MI	Plug flow, inground tank	1981	Dairy; 720	Electricity	0	Liquid/Slurry Storage	57	1,197
MN	Mesophilic, flexible top, plug flow, combined phase, concrete tank	1999	Dairy; 1,000	Electricity; hot water	99	Liquid/Slurry Storage	81	1,701
MN	Plug flow	N/A	Dairy; 3000	Electricity	N/A	Liquid/Slurry Storage	242	5,082
MS	Ambient temperature covered lagoon	1998	Swine; 145	Flare	4	Lagoon	5	105
NC	Ambient temperature covered lagoon	1997	Swine; 4,000	Electricity; hot water	108	Lagoon	140	2,940
NC	Mesophilic, covered lagoon, mix digestive	2003	Swine; 10,000	Electricity	135	Lagoon	350	7,350
NY	Mesophilic, flexible top, concrete tank, plug flow	1998	Dairy; 550	Electricity	117	Liquid/Slurry Storage	44	924
NY	Mesophilic, hard top, complete mix, metal above ground tank	1985	Dairy; 270	Cogeneration	58	Liquid/Slurry Storage	22	462
NY	Hard top	N/A	Dairy; N/A	N/A	N/A	Liquid/Slurry Storage	N/A	N/A
NY	Mesophilic, flexible top, plug flow, concrete tank	2001	Dairy; 850	Hot water	68	Liquid/Slurry Storage	68	1,428

Location	Digester Type	Year Operational	Animal Type/ Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
NY	Mesophilic, flexible top, complete mix, concrete inground tank	2001	Dairy; 750	Electricity; hot water	122	Liquid/Slurry Storage	60	1,260
NY	Plug flow	N/A	Dairy; 185	Flare	0	Liquid/Slurry Storage	15	315
NY	Mesophilic, hard top, plug flow, concrete inground tank	2003	Dairy; 1,300	Electricity	117	Liquid/Slurry Storage	104	2,184
NY	Mesophilic, hard top, plug flow, concrete tank	N/A	Dairy/swine; 2,080	Electricity	117	Liquid/Slurry Storage	167	3,507
OR	Mesophilic, hard top, complete mix, above ground	2001	Dairy; 325	Electricity	32	Liquid/Slurry Storage	30	630
OR	Mesophilic, flexible top, plug flow, concrete tank	2003	Dairy; 2,000	Electricity	225	Liquid/Slurry Storage	183	3,843
OR	Mesophilic, flexible top, plug flow, concrete tank	2004	Dairy/poultry; 2,000	Electricity	270	Liquid/Slurry Storage	183	3,843
PA	Mesophilic, flexible cover tank, plug flow, complete mix, slurry loop	1983	Layer; 350,000	Electricity; hot water	135	N/A	263	5,523
PA	Mesophilic, hardtop, complete mix, slurry loop, concrete tanks	1983	Layer; 75,000	Electricity	58	Liquid/Slurry Storage	56	1,176
PA	N/A	N/A	Swine; 1,200	Electricity	90	Lagoon	40	840
PA	Mesophilic, hard top, plug flow, complete mix, slurry loop, concrete tank	1979-1984	Dairy; 2,300	Electricity; hot water	225	Liquid/Slurry Storage	215	4,515
PA	Mesophilic, hard top, plug flow, complete mix, slurry loop, concrete tank	1983	Dairy; 250	Electricity	22	Liquid/Slurry Storage	15	315
PA	N/A	2004	Swine; 4,400	Electricity	117	Lagoon	148	3,108
PA	Mesophilic, flexible top, plug flow, complete mix, concrete tank	1985	Swine; 750	Electricity; hot water	180	Lagoon	25	525
TX	Mesophilic, plug flow, hard and flexible covers, lagoon	1989	Dairy; 400	Electricity	54	Liquid/Slurry Storage	57	1,197

Location	Digester Type	Year Operational	Animal Type/ Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
TX	Mesophilic, mixed covered lagoon	2003	Swine; 108,000	Electricity	1,800	Lagoon	3883	81,543
TX	Mesophilic, mixed covered lagoon	2003	Swine; 10,000	Electricity	144	Lagoon	360	7,560
UT	Mesophilic covered lagoon	2005	Swine; 144,000	N/A	N/A	Lagoon	3750	78,750
VA	Ambient temperature covered lagoon	1984	Swine; 3,000	Electricity	0	Lagoon	41	861
VT	Mesophilic, flexible top, plug flow, concrete tank	1982	Dairy; 340	Electricity; hot water; steam	76	Liquid/Slurry Storage	24	504
WA	Plug Flow	2005	Dairy; 1,500	Electricity	259	Liquid/Slurry Storage	418	8,778
WI	Mesophilic, hard cover, modified plug flow, concrete tank	2001-2	Dairy; 730	Electricity; heat	200	Liquid/Slurry Storage	107	2,247
WI	Mesophilic, flexible cover, plug flow, concrete tank	2001-2	Dairy; 1,200	Electricity; heat	140	Liquid/Slurry Storage	176	3,696
WI	Mesophilic, hard cover, modified plug flow, concrete tank	2001	Dairy; 2,400	Electricity; heat	375	Liquid/Slurry Storage	351	7,371
WI	Mesophilic, hard top, modified plug flow, concrete tank	2004	Dairy; 3,000	Electricity; heat	700	Liquid/Slurry Storage	439	9,219
WI	Mesophilic, hard top, modified plug flow, concrete tank	1998	Dairy; 1,100	Heat	N/A	Liquid/Slurry Storage	161	3,381
WI	Mesophilic, hard top, modified plug flow, concrete tank	1999	Dairy; 1,600	Heat	N/A	Liquid/Slurry Storage	234	4,914
WI	Mesophilic, hard top, modified plug flow, concrete tank	2001	Dairy; 875	Electricity; heat	135	Liquid/Slurry Storage	128	2,688
WI	Mesophilic, flexible top, complete mix, concrete tank	2004	Dairy; 1,350	Electricity; heat	350	Liquid/Slurry Storage	197	4,137

Location	Digester Type	Year Operational	Animal Type/ Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ¹ (MT/yr)
WI	Mesophilic, hard top, modified plug flow, concrete tank	2005	Dairy; 1,200	Electricity; heat	200	Liquid/Slurry Storage	176	3,696
WI	Thermophilic with co-digestion, hard top, complete mix, steel tank	2005	Dairy; 1,000	Electricity; heat	775	Liquid/Slurry Storage	146	3,066
WI	Thermophilic with co-digestion, hard top, complete mix, steel tank	2004	Dairy; 1,000	Electricity; heat	775	Liquid/Slurry Storage	146	3,066
WI	Mesophilic, hard top, modified plug flow, concrete tank	1988	Duck; 500,000	Electricity; heat	200	Liquid/Slurry Storage	603	12,663
WI	Thermophilic with co-digestion, hard top, complete mix, steel tank	2005	Dairy; 1,300	Electricity; heat	775	Liquid/Slurry Storage	190	3,990
WI	Mesophilic, hard top, complete mix, stainless steel tank	2006	Dairy; 1,000	Electricity; heat	250	Liquid/Slurry Storage	146	3,066
WI	Mesophilic, flexible top, complete mix, concrete tank	2006	Dairy; 2,500	Electricity; heat	500	Liquid/Slurry Storage	366	7,686
WI	Complete mix	2005	Dairy; 1,000	N/A	225	Liquid/Slurry Storage	79	1,659
WY	Mesophilic, complete mix	N/A	Swine; 5,000	Electricity	N/A	Lagoon	10	210
WY	Mesophilic, complete mix	N/A	Swine; 15,000	Electricity	N/A	Lagoon	458	9,618

Table 3. U.S. Digesters in Startup-Construction Stage

Location	Digester Type	Animal Type/Population	Biogas End Use	Operational Output (kW)	Baseline System	Methane Emission Reduction (MT/year)	Equivalent GHG Emission Reduction ² (MT/yr)
IL	Plug flow	Dairy; 1,000	Electricity	N/A	Liquid/Slurry Storage	101	2,121
IN	Plug flow	Dairy; 3,200	Electricity	N/A	Liquid/Slurry Storage	314	6,594
NE	Complete mix	Swine; 6,000	Electricity	144	Liquid/Slurry Storage	82	1,722
NY	Complete mix	Duck	Electricity	N/A	Liquid/Slurry Storage	N/A	N/A
NY	Plug flow	Dairy; 170	Electricity	22	Liquid/Slurry Storage	14	294
NY	Plug flow	Dairy; 700	Electricity	63	Liquid/Slurry Storage	56	1,176
NY	Plug flow	Dairy	Electricity	N/A	Liquid/Slurry Storage	N/A	N/A
NY	Complete mix	Dairy; 1,800	Electricity	234	Liquid/Slurry Storage	144	3,024
PA	Plug flow	Dairy; 700	Electricity	72	Liquid/Slurry Storage	65	1,365
PA	Plug flow	Dairy; 400	Electricity	45	Liquid/Slurry Storage	37	777
PA	Plug flow	Dairy; 400	Electricity	45	Liquid/Slurry Storage	37	777
PA	Plug flow	Dairy; 600	Electricity	36	Liquid/Slurry Storage	56	1,176
VT	Two-stage mixed	Dairy; 1,200	Electricity; flare; cogeneration	216	Lagoon	254	5,334
WI	Mesophilic, hard top, modified plug flow, concrete tank	Dairy; 3,000	Electricity, heat	1,200	Liquid/Slurry Storage	230	4,830
WI	Mesophilic, hard top, modified plug flow, concrete tank	Dairy; 3,000	Electricity, heat	600	Liquid/Slurry Storage	230	4,830
WI	Mesophilic, hard top, modified plug flow, concrete tank	Dairy; 800	Electricity, heat	150	Liquid/Slurry Storage	62	1,302
WI	Mesophilic, hard top, modified plug flow, concrete tank	Dairy; 1,050	Electricity, heat	200	Liquid/Slurry Storage	80	1,680
WI	Mesophilic, hard top, modified plug flow, concrete tank	Dairy; 3,000	Electricity, heat	300	Liquid/Slurry Storage	230	4,830
WI	Mesophilic, flexible top, complete mix, concrete tank	Dairy; 2,500	Electricity, heat	500	Liquid/Slurry Storage	191	4,011

² Equivalent greenhouse gas emission reduction potential expressed as carbon dioxide. This value assumes methane has approximately 21 times the heat trapping capacity of carbon dioxide.

So what are the potential GHG benefits and how are they calculated?

Similar data were reported in the last edition of the Digest, and a number of inquiries were submitted requesting clarification on how methane reduction values were calculated.

Recognizing that there is great variability in methane emissions from animal waste management systems, it is necessary to establish an emission profile for a specific waste management system (see Table 4). To represent this variability, Methane Conversion Factors (MCFs) are used in combination with B_0 , the Ultimate

Methane Yield, and other key parameters. For new farms where there is no existing animal waste management system, the state requirement for the specific animal specie, farm scale, and waste handling method should be used.

Table 4. Livestock Manure Management Systems and Methane Emission Factors by Climate Type

Manure Management System									
Climate	Uncovered Lagoon	Liquid/Slurry Storage	Solid Storage	Dry Lot	Pit less than 1 Month	Pit more than 1 Month	Daily Spread	Digester	Other
Cool	90%	10%	1%	1%	5%	10%	0.1%	10%	1%
Temperature	90%	35%	1.5%	1.5%	18%	35%	0.5%	10%	1%
Warm	90%	65%	2%	5%	33%	65%	1%	10%	1%

There are essentially two steps to this process. The first step is to determine a baseline emission profile. This involves calculating annual methane emissions from the existing animal waste management system. The second step is to calculate avoided CO_2 emissions when the project uses

gas to generate electricity, recognizing that the electric utility does not need to combust fossil fuels to generate the energy produced by the digester system. The sum of step 1 and step 2 will determine the greenhouse gas reductions achieved through the project. Table 5 illustrates the method

and comparative reductions relative to two baselines (a liquid manure storage and a combined treatment and storage lagoon) animal waste management systems for 500 milk cows.

Table 5. Comparison of Methane Emission Reductions for Two Example Systems

Factors	Manure Storage Tank or Pond	Conventional Anaerobic Lagoon
Methane emission reductions		
Number of cows	500	500
Average live weight, lb/cow	1,400	1,400
Total volatile solids (VS) excretion rate, lb/1,000 lb live weight_day	8.5	8.5
B_0 , ¹ ft ³ /lb VS	3.84	3.84
MCF, ² decimal	0.292	0.707
Methane density, lb/ft ³	0.041	0.041
Methane emissions, ³ tons/yr	50	121
Methane emission reduction from biogas capture and utilization, ⁴ ton/yr	50	121
Equivalent reduction in carbon dioxide emissions, ⁵ tons/yr	1,048	2,538
Displaced emissions from utility electric generation		
Methane production, ft ³ /yr @ 38.5 ft ³ /cow_day	7,026,250	7,026,250
Electricity generation potential, ⁶ kWh/yr	467,838	467,838
Reduction in utility carbon dioxide emissions, ⁷ tons/yr	526	526
Total greenhouse gas emission reduction as carbon dioxide, tons/yr	1,574	3,064

¹ B_0 = Maximum methane generation potential, m³ methane/kg VS.

² U.S. average MCF for manure storage tanks and ponds, and conventional anaerobic lagoon.

³ Methane emissions = number of cows * average live weight * VS excretion rate * 1/1000 * B_0 * MCF * methane density * 365 days/yr * ton/2000lb.

⁴ Biogas combustion destroys essentially 100% of baseline methane emissions.

⁵ Methane has approximately 21 times the heat trapping capacity of carbon dioxide.

⁶ Generation, kWh/yr = methane production * 1,010 Btu/ft³ of methane * kWh/3413 Btu * 0.25 (methane to electricity conversion efficiency) * 0.9 (on-line efficiency)

⁷ Assuming 2,249 lb of carbon dioxide emitted per mWh generated from coal (Spath et al., 1999).

Dairies Profit from Greenhouse Gas Market



(Photo courtesy of ECC)

Dairy farmer Darryl Vander Haak receives his first check for carbon credits from Jim Jensen of Environmental Credit Corp.

Environmental Credit Corp. (ECC), a supplier of environmental credits to global financial markets, delivered the first payments to U.S. dairy farmers for greenhouse gas reductions. Darryl Vander Haak, a dairy farmer in Lynden, WA, and Dennis Haubenschild, from Princeton, MN, received their first checks for capturing methane from manure on their farms using anaerobic digesters.

these two projects are worth more than \$26,000.

ECC, a member of the Chicago Climate Exchange (CCX), worked closely with the farmers to monitor and certify their methane emission reductions, formally registering them with the CCX in October. The CCX is the world's first (and North America's only) voluntary, legally binding rules-

"It's one more revenue stream that helps us keep producing milk for our customers," said Vander Haak. Combined, the two dairy farmers were credited with preventing the release of over 720 tons of methane to the atmosphere - equivalent to more than 13,000 metric tons of carbon dioxide. The "carbon credits" produced by

based greenhouse gas emissions allowance trading system. CCX provides farmers the opportunity to receive greenhouse gas credits for environmentally friendly farming practices such as methane combustion and destruction from anaerobic manure digestion. Farmers can then sell these greenhouse gas credits through the exchange to willing buyers.

With about eight million dairy cows in the U.S., potential revenues to the dairy industry from carbon credits could exceed tens of millions of dollars annually as the greenhouse gas market grows. Dozens of farmers have already applied to enroll in ECC's carbon credit program.

For farmers interested in ECC's carbon credit program, Jim Jensen can be contacted at: (814) 235-1623 or jjensen@envcc.com. ECC's Web site is at www.envcc.com.

Story courtesy of ECC.

The **Methane to Markets Partnership** is an international initiative whose purpose is to reduce global methane emissions to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse emissions. The Partnership is a collaborative between developed countries, developing countries, and countries with economies in transition - together with strong participation from the private sector. The Partnership was launched on November 16, 2004, at a Ministerial meeting in Washington, D.C. where 14 countries signed into the partnership to reduce emissions from the coal, natural gas, and landfill sector. The livestock sector was added during a November 2005 meeting in Buenos Aires, Argentina, and now is a formal subcommittee of the Partnership focused on reducing emissions and other environmental impacts from livestock waste. For more info see the Web site at www.methanetomarkets.org.

Hilarides Dairy Demonstrates Energy and Environmental Success



A.J. Yates and Rob Hilarides at a Hilarides Dairy Open House.

The Hilarides Dairy in Lindsay, Tulare County, California, recently displayed its methane gas-powered generators to nearly 100 visitors, giving them a glimpse of how dairy cow manure is powering their operations while benefiting the environment. CDFA Undersecretary A.J. Yates was among the many officials on hand and praised owner Rob Hilarides for “turning a waste product into an energy product.”

Hilarides has doubled its original generating capacity to 500 kilowatts, and now four generators provide approximately 90% of the dairy’s electrical power. The digester uses manure from the nearly 6,000 dairy heifers and steers at the Sierra Cattle Co. run by Hilarides. In addition to the electricity generated, it cuts down on odor, captures methane gas before it reaches the

atmosphere, and helps reduce the strain on the California power grid.

Michael Marsh, CEO of Western United Dairymen, noted that dairy producers are benefiting from a WUD-sponsored law that extends net metering to December 31, 2009.

Under net metering, electricity generated by biogas can be credited against electricity consumed.

However, Marsh and others were quick to point out that a greater incentive for more digester projects would be “having the dairy producer get paid for the power he’s generating.” He pointed out that a mandate that utilities purchase excess power would be a greater economic incentive for dairy producers when weighing the costs of building a methane-powered generator.

About half of the Hilarides Dairy digester’s \$1 million cost was paid by the California Dairy Power Production Program (DPPP), which is administered by Western United Resource Development for the California Energy Commission. Fourteen projects have been approved for DPPP grants, totaling nearly \$58 million. The projects have an estimated generating capacity of nearly 3.5 megawatts.

